The Use of the Lakatos-Hickman Relay in a Subscriber Sender - Case 20878

MM-40-130-179

August 13, 1940

MEMORANDUM FOR FILE

The Lakatos-Hickman type relay[1] using the relay springs as part of the magnetic circuit can be used as a very economical type of pulse counter and registration device. In fact, one such relay with twenty moving springs can count and register up to ten pulses, while the same operation requires at least five ordinary relays, and some standard circuits use as many as twenty to reduce the spring loading on the relays and the contact loading in the pulsing circuit. It has been suggested that this new type of relay might be used for some or all of the many counting, steering, and registration circuits in a subscriber type sender. The present memorandum gives some circuits for accomplishing this. The chief problem in the design of these circuits is that of performing the various translating operations necessary in converting the incoming pulses into group and brush selections, or P.C.I. pulses as the case may be, without using more contact elements than are available on the counting relay. Two different solutions are given here. The first was made as economical as possible but at the cost of one disadvantage. Under certain conditions of contact failure in the thousands or hundreds register the sender will connect the subscriber to an incorrect number rather than connecting to a tell-tale and giving him a busy signal. The second circuit, which we will call the positive action circuit[2], is designed to overcome this difficulty but does so at the expense of more contacts and wiring. Some compromise between these circuits may be the most desirable. The circuits by no means represent a complete sender. It appears that the problems connected with the office code (i.e. the first two or three digits) can be handled without much difficulty. At any rate these circuits will depend on the type of decoder used, and would represent a second stage in the design. We have therefore designed what might be called a "four digit sender" considering only the problems arising in the thousands, hundreds, tens and units digits. We also have omitted consideration of the parts of the circuit used for control and supervisory purposes, since these can be easily handled by existing circuits, and do not directly involve the new type relay. Our chief purpose is to

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[1]See "Circuit Analysis for Lakatos-Hickman Type Relay", G. R. Stibitz, MM40-130-126, Jan. 15, 1940, Case 20878.

[2]This circuit was suggested by Mr. G. V. King

show that the new type counter contains sufficient contact elements for most of the steering and counting circuits of the subscriber sender. It is always possible to add more contacts at any stage in the new type counter by the arrangement of springs in Fig. 1, but this would be undesirable from the standpoint of standardization. At any rate it was found that even in the positive action circuit, only two stages in one register needed more contacts than are already available, and two additional ordinary relays were introduced here to carry the contact load.

It should be pointed out that an extremely simple and economical sender (i.e., much simpler than those given here) could be designed using the new type counter were it not for the peculiar translation codes involved. Thus if we could start "from scratch" and design translation codes particularly adapted to the characteristics of the new relay, the circuits could be made very simple indeed. Even using the existing codes which were constructed to simplify the present type circuits, the use of the new counter allows a remarkable simplicity and economy.

The circuits were designed by a combination of common sense and Boolean algebra methods. We will omit the details involved in their design. Although it is possible that a few superfluous elements remain, it is doubtful if they can be simplified very much.

Figure 2 is a block diagram of the proposed sender. In the present panel and crossbar senders, pulse counting is done in the same circuit for each digit and the numbers transferred from this counting circuit to a set of registering circuits, one for each digit, through an incoming steering chain. The registering circuits in the panel type sender consist of a set of five ordinary relays per digit, while in the crossbar system the A digit is registered on one or two verticals of a crossbar switch. In Figure 2, on the other hand, each digit has one of the new type counter relays which acts both as a pulse counter and as a register. The incoming steering chain steers the incoming pulses to the correct counter-register rather than steering the number recorded by the input pulse counter to a digit register. The input steering chain may or may not be one of the new type counters. The steering operation can be done with the new type counter, but it appears to require special devices, as for example polarized springs, in order to energize both windings of the register relays after receiving a digit. Even using the present type of steering chain a great simplification is possible, for only one wire, the pulsing lead, needs to be steered to the various digit registers, rather than the five leads of the present type sender. Another possibility is using a new type counter to count the groups of pulses and operate a set of relays S_A, S_B,

S_C, S_{TH}, S_H, S_T, S_U which come in after the A, B, C, TH, H, T, and U digits are received and energize both coils of the corresponding registers.

After the digits are registered on the new type counters, these numbers are translated by means of the contact interconnections into the code corresponding to the incoming brush, incoming group, final brush, tens, and units selections, which are represented by a ground on one of the leads in the groups marked IB, IG, FB, T, and U, respectively. These groups of leads are connected in sequence to the revertive pulse counter by means of the revertive group counter. The revertive pulse counter will be one of the new type relays and is connected in such a way as to open the fundamental circuit and thus stop the revertive pulsing when it reaches the first ground. The revertive group counter or revertive steering chain, of course, steps ahead after each group of revertive pulses through the action of a slow release relay. This last steering operation cannot be done solely with one of the new type relays for it is necessary to steer ten leads in the tens and units digits. It could be done, however, with a new type counter in conjunction with four ordinary relays.

In the case of a call to a manual office the outputs of the digit registers are translated by a P.C.I. circuit into the correct P.C.I. codes. This circuit, too, can make use of the new type counter in the quadranting operation, i.e. in apportioning four quadrants to each of the four digits to be transmitted. This would be done with a sixteen stage counter (or if it is desirable to have all counters with ten stages, two of these could be connected "in series") replacing the present sequence switch.

Of course there must be an interlock between the incoming and revertive steering chains to prevent any selection being made before sufficient information has been received. This can be done by fairly standard methods.

A rough comparison can be made between the relay requirements of the present panel type sender and the design proposed here. Omitting parts of the circuit which would be substantially the same the requirements are listed below:

	Present Panel Sender	Proposed Sender	
Operation	Ordinary Relays	New Type Counters	Ordinary Relays
Input Counting	12	-	-
Input Steering	16	1	-
Registration	38	8	2
Revertive Counting	20	1	-
Revertive Steering	10	1	5
Total	96	11	7

In addition, a sequence switch is replaced by a new type counter. These figures are based on the positive action circuit. The other circuit uses 6 ordinary relays. This comparison of the numbers of relays involved shows only a small part of the saving, however. The wiring and fundamental method of operation of the new circuit is much simpler which tends both toward economy and, providing the new relay can be made sufficiently reliable, elimination of faults and errors.

It is a little more difficult to give a quantitative comparison of the proposed sender with the present crossbar type sender due to the differences in the types of circuit elements involved, but it appears that the saving would be of the same order of magnitude.

The new type counter with ten stages acts like a series of twenty relays which come in sequentially as the two coils of the relay are alternately energized. Thus after n pulses the first 2n relays are operated. If, after a series of pulses only one of the two coils on a counter remains energized we can only be sure of the contacts on that side. It was found that under these conditions the number of contacts available was far too small in all of the four registers for the various translating operations necessary. We have therefore assumed the steering circuit should be designed in such a way as to energize both coils of a counter after it has received its series of pulses.* This insures the contacts on both sides and each stage then has the equivalent of two transfer contacts and two additional contacts somewhat similar to a switchhook connection. Thus each stage may be considered as a relay with the contacts available indicated in Figure 3. Our circuit diagrams are drawn from this point of view.

For the convenience of the reader we will list the various translation codes used in the sender. The incoming brush selection depends only on the thousands digit and is given by the following table:

Thousands Digit	Incoming Brush Selection
0, 1	0
2, 3	1
4, 5	2
6, 7	3
8, 9	4

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*See the memorandum "Circuit Arrangement for Counting Relay with Mechanically Independent Contact Springs", by B. D. Holbrook, MM-40-130-149, July 5, 1940, Case 22108-1.

The incoming group selection depends on both the hundreds and thousands digits and is given by the following:

Thousands Digit	Hundreds Digit	Incoming Group Selection
even	< 5	0
even	≥ 5	1
odd	< 5	2
odd	≥ 5	3

The final brush selection depends only on the hundreds digit. We have the following code:

Hundreds Digit	Final Brush Selection
0, 5	0
1, 6	1
2, 7	2
3, 8	3
4, 9	4

It should be remembered that an incoming brush, incoming group, or final brush selection of n corresponds to n + 1 revertive pulses. The same remark applies to the tens and hundreds selection.

Digits are sent to a call indicator by series of positive and negative pulses, four for each digit. Two different codes are used for this, one for the thousands digit and the other for the hundreds, tens, and units. The thousands code is an additive one based on the numbers 1, 2, 4, and 8 as follows:

P.C.I. Code for Thousands Digit

Thousands Digit	Quadrant I	II	III	IV
1	0	0	0	-
2	-	0	0	0
3	-	0	0	-
4	0	-	0	0
5	0	-	0	-
6	-	-	0	0
7	-	-	0	-
8	0	0	-	0
9	0	0	-	-
0	0	0	0	0
Corresponding Additive Numbers	2	4	8	1

The sum of the numbers corresponding to the columns in which a digit has the symbol - gives that digit, hence the additive property of the code. In this table I, II, III, and IV refer to the four pulses or quadrants. In the first and third quadrants 0 represents a ground and a - represents a positive pulse. In the even quadrants 0 means a light negative pulse and the -, a heavy negative pulse. We have chosen this representation of the code for comparison with the P.C.I. circuit in which four leads are grounded or not in accordance with the above table. Thus if the digit 3 is registered in the thousands place, leads II and III in a group I, II, III, IV are grounded. The presence or absence of these grounds are translated into positive or negative pulses by two relays TS and RS.

The hundreds, tens, and units P.C.I. code is also additive based on the numbers 1, 2, 4, 5. Using the same conventions it is represented by the following table:

P.C.I. Code for Hundreds, Tens, and Units Digits

H, T, or U Digit	Quadrant I	II	III	IV
1	-	0	0	0
2	0	-	0	0
3	-	-	0	0
4	0	0	-	0
5	0	0	0	-
6	-	0	0	-
7	0	-	0	-
8	-	-	0	-
9	0	0	-	-
0	0	0	0	0
Corresponding Numbers	(1)	(2)	(4)	(5)

The circuit for the tens or units register is shown in Figure 4. The operation is quite obvious. In the case of a full mechanical call, if 6 for example were dialed in the tens place, the first six relays are locked in, which places a ground on the lead marked 6. These are connected through the revertive steering chain to the revertive counter which reaches this ground after the seventh revertive pulse. The presence of this ground operates a relay which opens the fundamental circuit and stops the pulsing. A ground is also put on leads II and III for a P.C.I. call. The operation of the P.C.I. circuit will be described later. The thousands and hundreds register is shown in Figure 5 for the positive action circuit and in Figure 6 for the more economical circuit. In Figure 5, many of the contacts do double duty, translating both for P.C.I. and full mechanical calls. This is done through a relay P which is operated for a manual call and not for a mechanical call. In the hundreds register there were not enough contacts available in the fifth and tenth stages.

The relays R and S are used to carry part of the contact load. This circuit is designed so that one and only one of the IB, IG, and FB leads is grounded for a given number. In case of a contact failure none would be grounded and the corresponding commutator would supposedly go to a telltale. In the circuit of Figure 6, on the other hand, more than one of the IB, IG, or FB leads may be grounded at the same time. Thus if the thousands digit is 6, both 3 and 4 in the IB group are grounded. If the back contact on 8 failed the revertive pulse counter would not stop the pulsing action at brush 3 as it should but would go on to the fourth brush. However, this circuit is considerably simpler than Figure 5, and does not appear worse from the standpoint of possible wrong numbers than the present type of sender.

The P.C.I. circuit is shown in Figure 7. X is a relay which is operated in the odd quadrants and not in the even quadrants. TS and RS are relays whose windings are connected sequentially through the P.C.I. impulse chain to first the thousands P.C.I. leads I, II, III, and IV, then the hundreds, etc. according to the following table:

	Pulsing Stage		TS	RS
Th Digit	(1	X	Th I	Th II
	(2	-	Th III	Th II
	(3	X	Th III	Th IV
	(4	-	H I	Th IV
H Digit	(5	X	H I	H II
	(6	-	H III	H II
	(7	X	H III	H IV
	(8	-	T I	H IV
T Digit	(9	X	T I	T II
	(10	-	T III	T II
	(11	X	T III	T IV
	(12	-	U I	T IV
U Digit	(13	X	U I	U II
	(14	-	U III	U II
	(15	X	U III	U IV
	(16	-	-	U IV

In the odd quadrants X is operated, placing a ground on the fundamental ring (FR). The fundamental tip (FT) is connected through X to either ground or positive battery according as TS is operated or not. This depends of course on the condi-

tion of the P.C.I. lead to which TS is connected at the time. Similarly in the even quadrants light or heavy voltage is applied to FR according to the condition of RS while FT is grounded.

Figure 8 shows the revertive steering chain and revertive pulse counter.

C. E. SHANNON
C. E. S.

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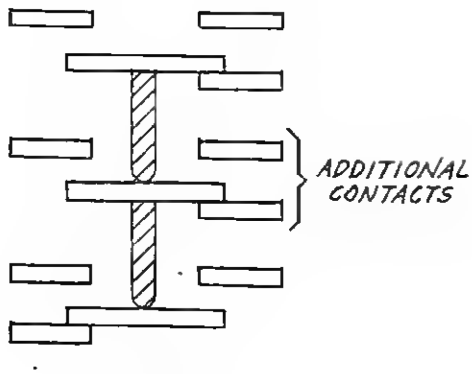

FIG. 1

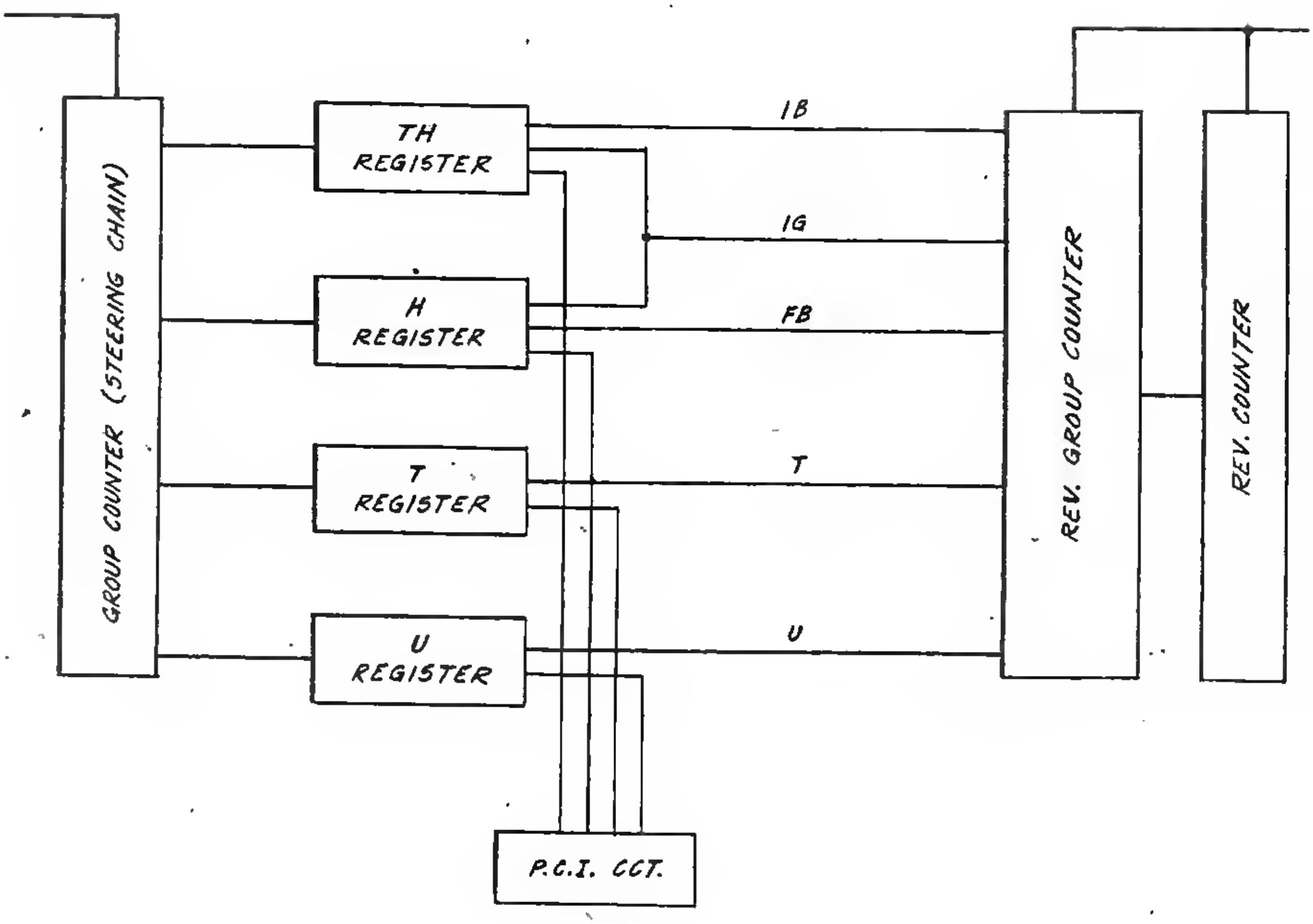

FIG. 2
BLOCK DIAGRAM OF SENDER

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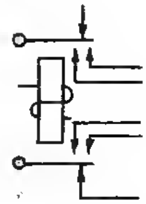

FIG. 3

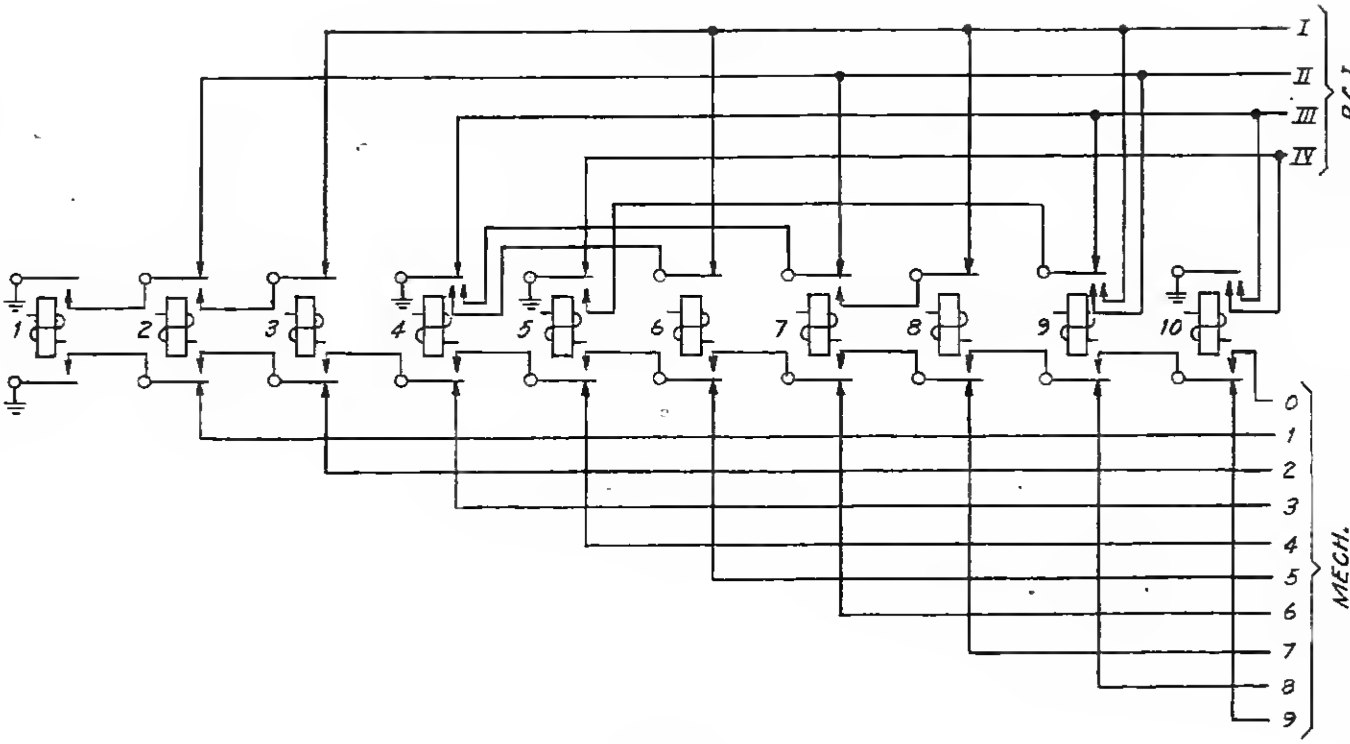

FIG. 4

TENS OR UNITS REGISTER

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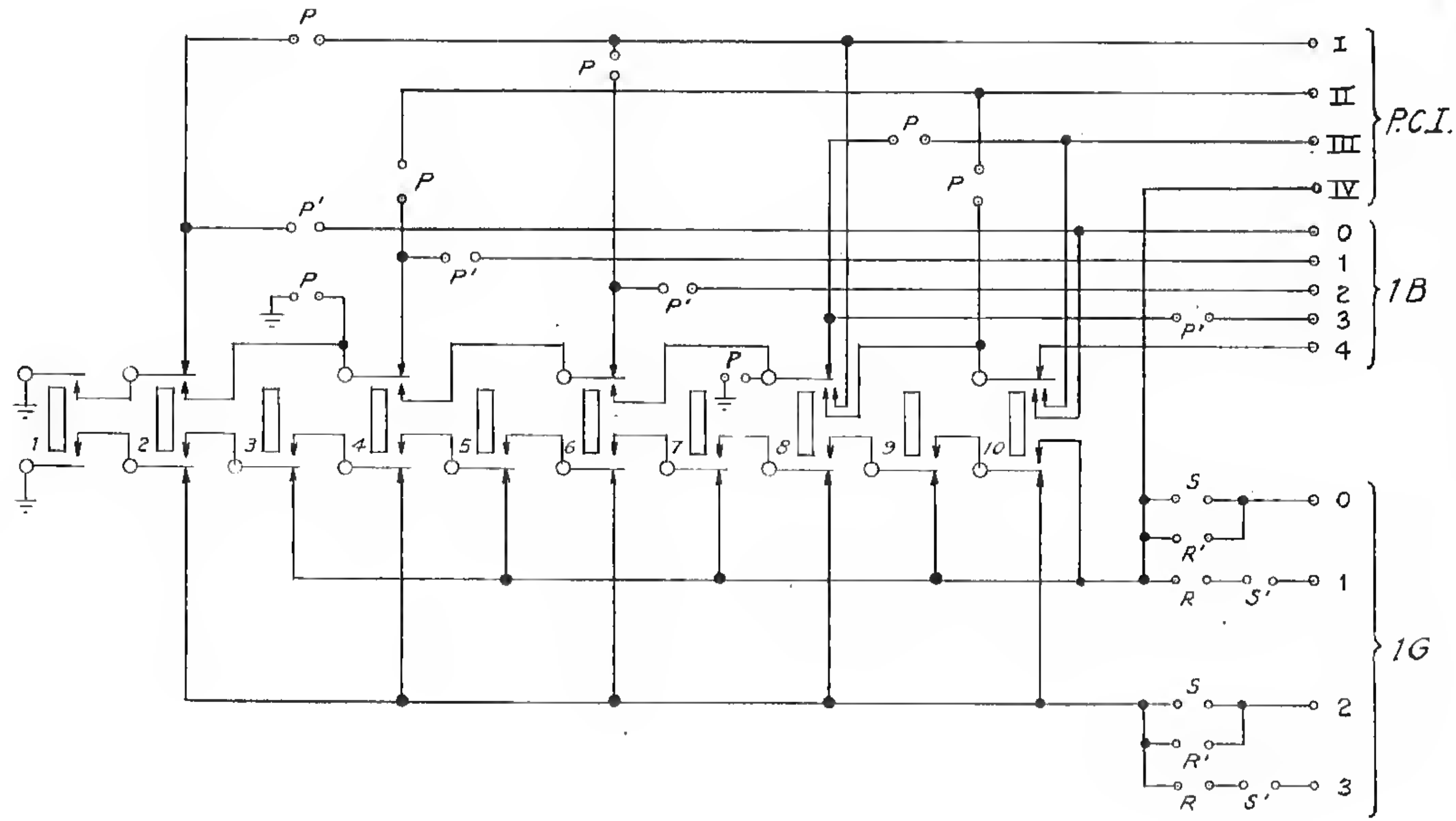

FIG. 5a
THOUSANDS REGISTER
POSITIVE ACTION CIRCUIT

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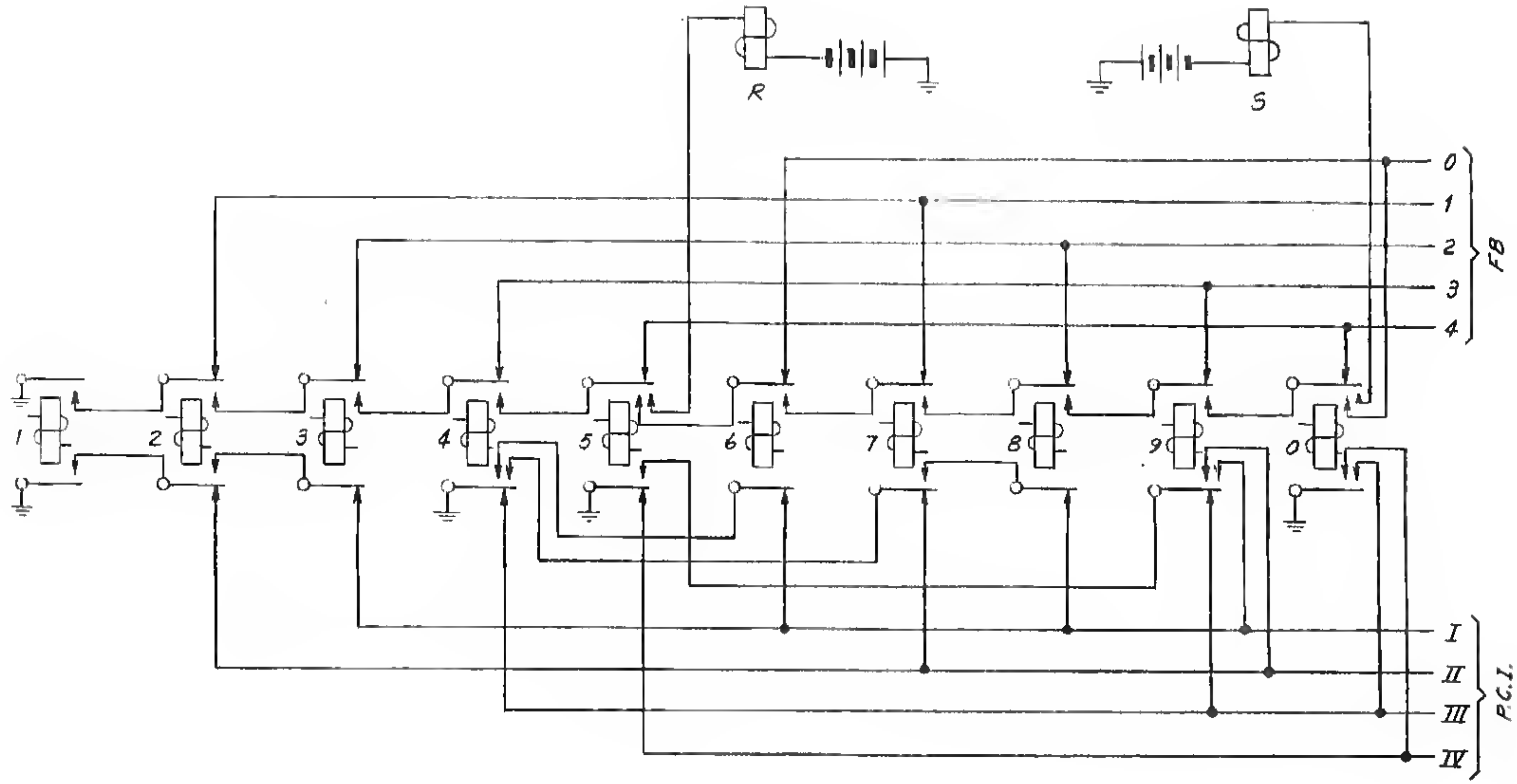

FIG. 5b

HUNDREDS REGISTER, POSITIVE ACTION CIRCUIT

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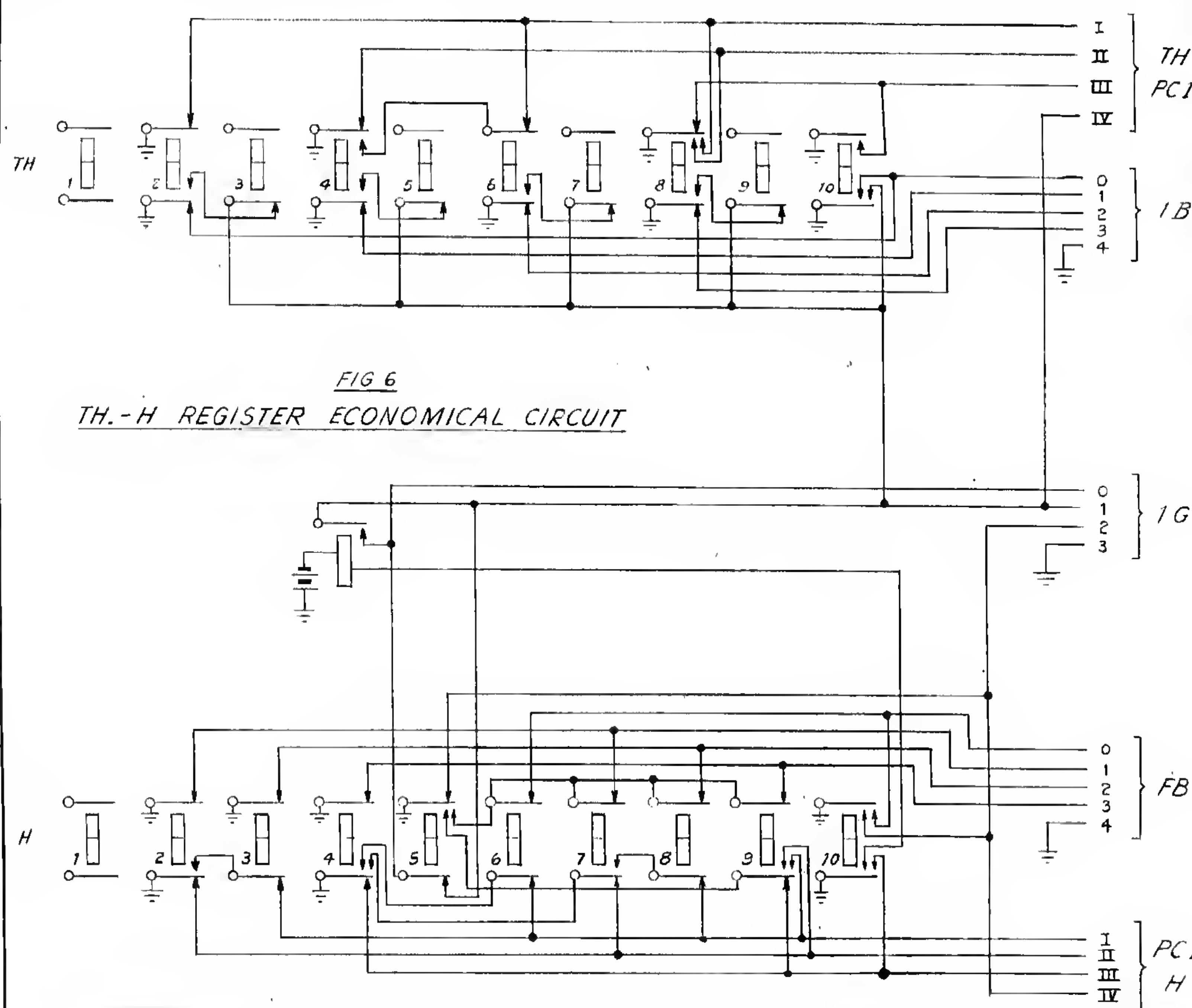

FIG 6

TH.-H REGISTER ECONOMICAL CIRCUIT

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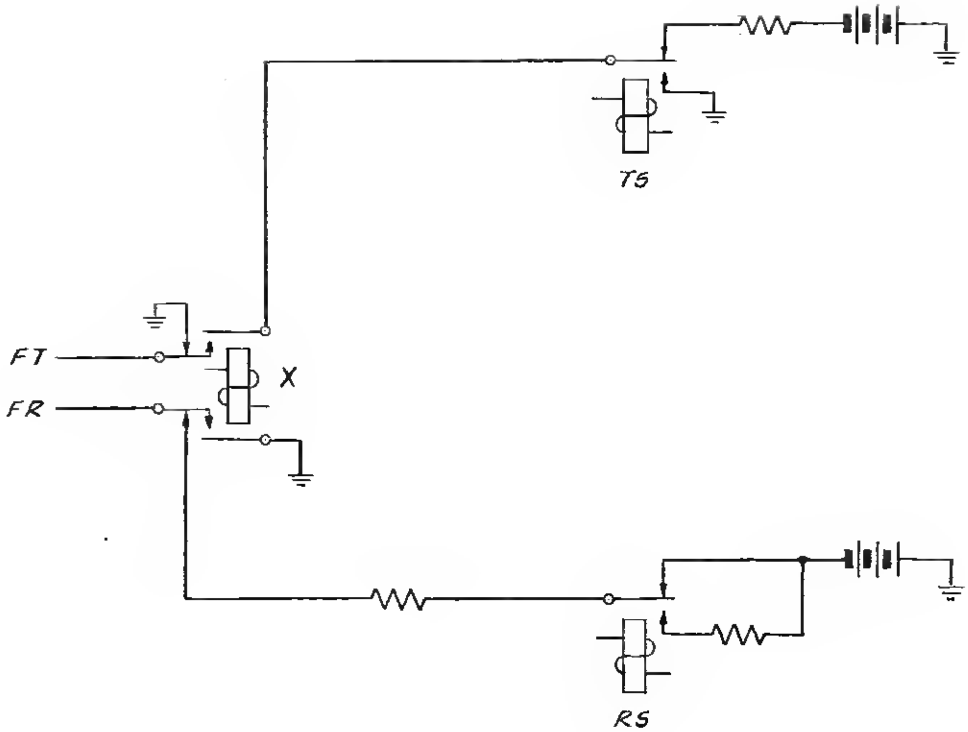

FIG. 7

P.C.I. CIRCUIT

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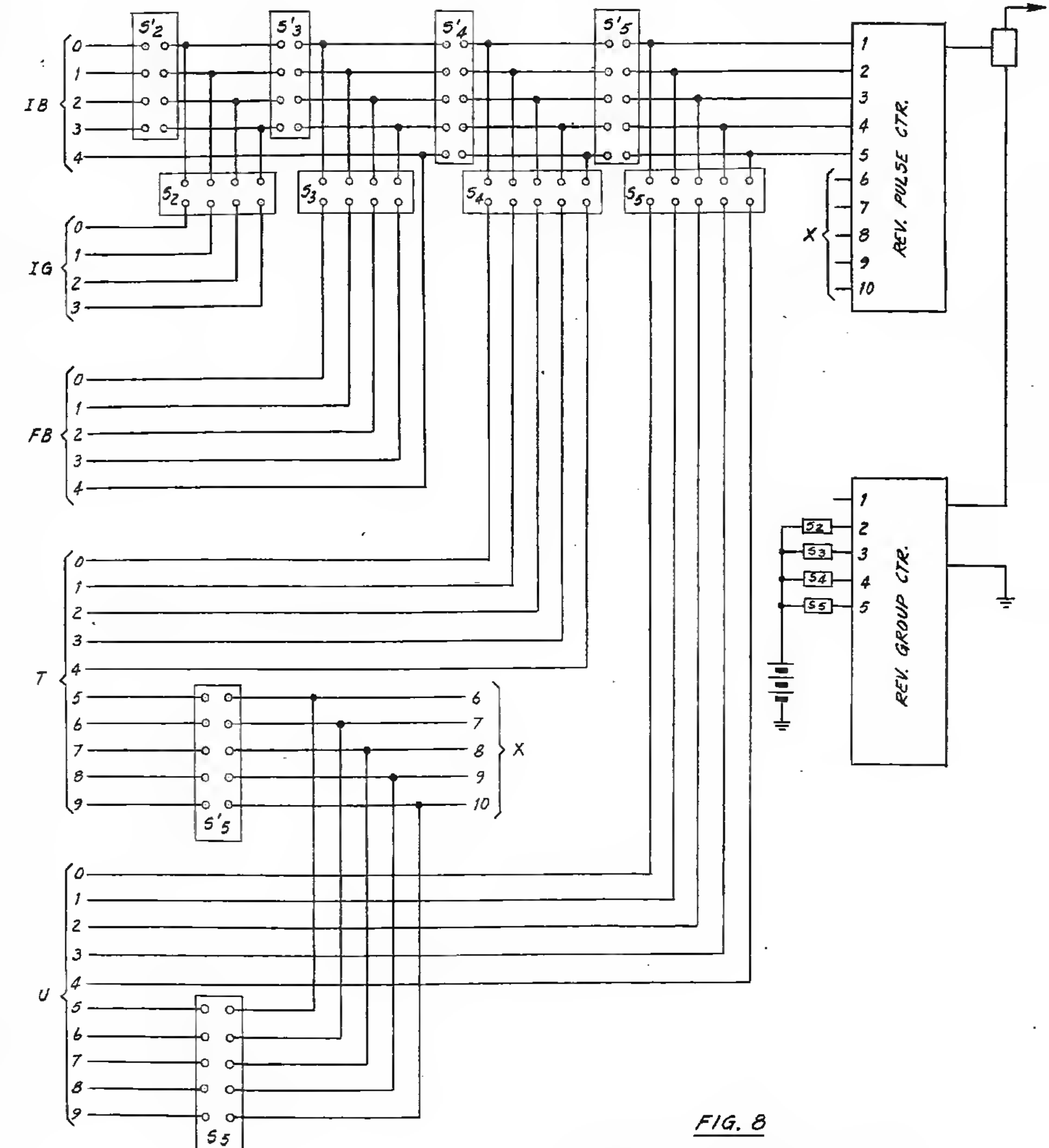

FIG. 8

REVERTIVE STEERING CHAIN

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